Space Weather Technical Forecast

Issued on Thursday, 08 December 2022 at 01:27 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of M-Class flares throughout. Chance of G1/Minor Storms Day 1. Chance of Active electron fluence Day 2 onwards.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low over the past 24 hours, with occasional to frequent low level C-class flares observed, including a including a peak C5.88 at 07/1304 UTC originating from AR3157. There are eight sunspot regions on the visible disc, dominated by a large region in the south centre disk, AR3153, which, despite its size, remains relatively stable. Two other regions in the northeast have shown some minor development and change in magnetic complexity. The remaining spots on the disk have shown little growth and remained relatively stable.

There is no evidence of any Earth-directed Coronal Mass Ejections (CMEs) in available satellite imagery.

Solar Wind / Geomagnetic Activity: Solar winds, as observed at L1 by DSCOVR, were initially at Slow-Ambient levels around 320 km/s and are currently around 460-480 km/s. A sudden jump in winds was observed around 07/0900 UTC to 370 km/s with a further upward trend to the current Slightly-Elevated levels attributed to the approach and arrival of a HSS from CH53/-. The solar wind density was initially at or below average, but increased to above average by 07/0700 UTC with a max reading of 51ppcc at 07/1440 UTC. The IMF Bt, was Weak initially, before becoming Moderate from 07/0900 UTC and Strong 07/1420-1830 UTC with a peak of 20 nT around 07/1540 UTC. The north-south component was initially mostly negative, ranging from +1 to -13nT. Since around 07/1600 UTC, the north-south component has been largely positive, ranging from -7 to +17nT. The phi angle remained positive (away from the Sun) until around 07/1200 UTC, after which, there have been lengthy periods of negative (towards the Sun).

Geomagnetic activity was initially Quiet (Kp 0-2) before becoming Unsettled to Active (Kp 3-4) with two G1/Minor Storm intervals observed (1200-1500 & 1500-1800 UTC).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES16 has remained at Background levels.

High energy electron flux (greater than 2 MeV), as observed by GOES16, was demonstrating a diurnal oscillation between Moderate and High flux levels, peaking at 2500 pfu at 07/1310 UTC.

Flux fell to Background levels around 07/1745 UTC where it has since remained. The associated 24-hour Fluence remained just below the Active (1e8 integrated pfu) threshold through the period. Observed fluence at 08/0001 UTC was 5.65e7 integrated pfu.

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Met Office Space Weather Technical Forecast

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is forecast to remain at Low levels, with occasional C-class flares and a daily Chance of isolated M-class flares, most likely from AR3153 or AR3157. Although one region may emerge across the eastern limb on Day 1, no significant regions are expected to arrive or depart in the next four days.

Solar Wind / Geomagnetic Activity: No Earth-directed CMEs have been observed on available imagery. Solar winds are currently at Slightly-Elevated levels and are anticipated to become Elevated due to enhancement from the arrival of a HSS from CH53/-. Solar wind enhancement will likely persist through Days 1 and 2 (8-9 Dec) before steadily declining as the HSS influence from CH53/- wanes.

Geomagnetic activity is expected to be initially Unsettled, with Active intervals Likely and a Chance of further G1/Minor Storms on Day 1 due to the arrival of fast winds from a coronal hole. Geomagnetic activity is expected to return to Quiet by Day 2 (9 Dec), with a diminishing Chance of Unsettled intervals.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) is expected to remain at Background levels throughout, with a daily very Slight Chance of seeing S1 levels if any significant flares were to occur. High energy electron flux (greater than 2 MeV), as observed by GOES16 are expected to remain at largely Background levels on Day 1 (8 Dec) in response to geomagnetic activity related to CH53/-. As influence from the HSS wanes, a recovery in electron flux levels is probable by Days 2 and 3 (9-10 Dec).

Levels of electron fluence are currently at Background levels, but very close to the Active threshold (1e8 integrated pfu). A decline is expected through Day 1 associated with the arrival of the HSS, with a gradual recovery from Day 2 (9 Dec), once more giving a Chance of Active fluence levels.

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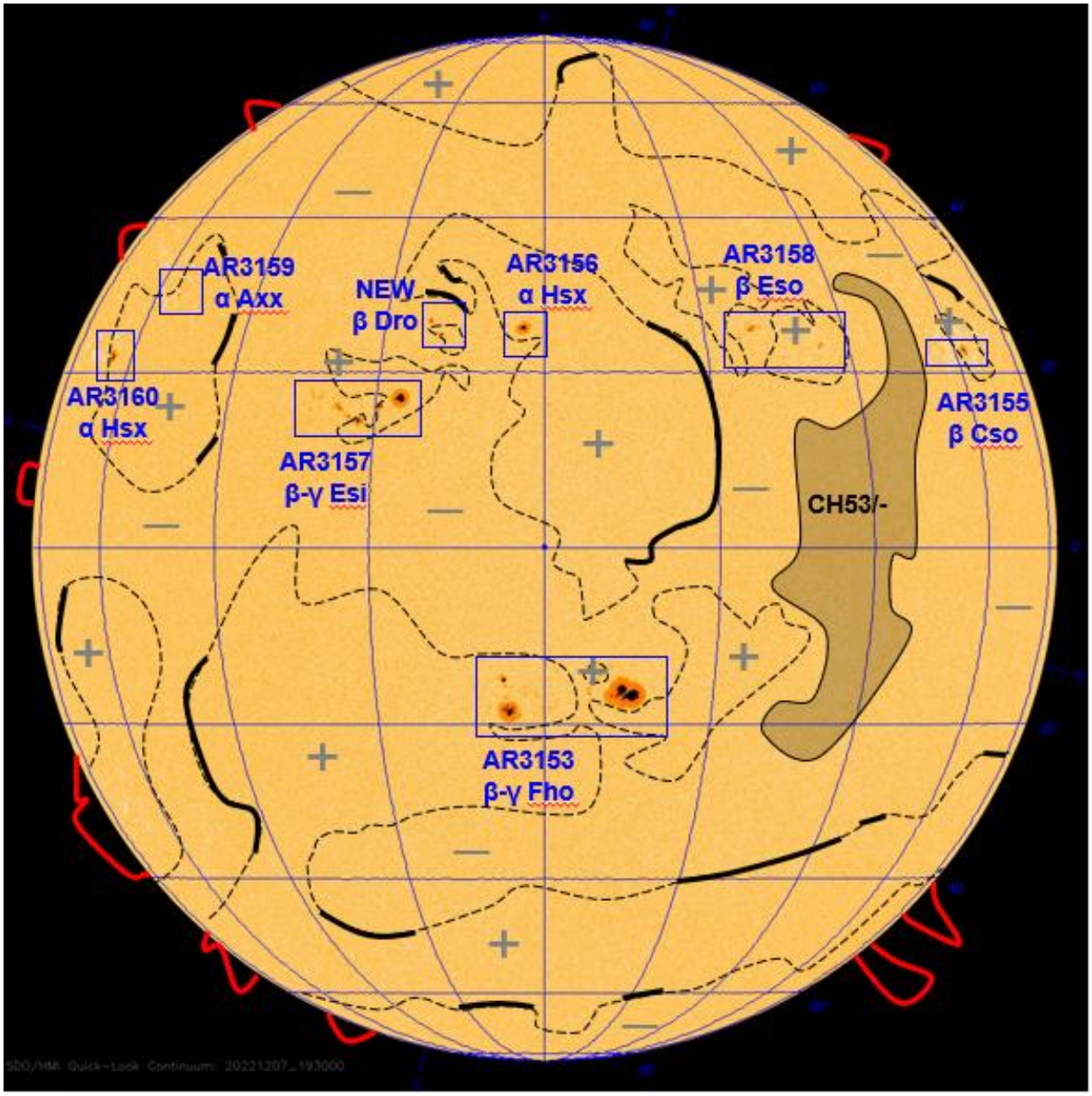
Figure 1. Solar Analysis Valid 07/1930 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Geomagnetic Storms:

No Earth-directed CMEs have been observed on available imagery.

Solar wind speeds have been on a gradual incline and are currently at Slightly-Elevated levels. Winds are expected to increase further to Elevated due to enhancement from the arrival of a HSS from CH53/-. CH53/- is a large coronal hole which dominates the western disc in SDO/AIA 211 and 193 imagery. This recurrent feature is larger and much more pronounced relative to the last rotation. Uncertainty as to the effect of this feature lies with these changes as well as the temporal proximity to the solstice and bi-annual minima. Solar wind enhancement will likely persist through Days 1 and 2 (8-9 Dec) before steadily declining through the remainder of the

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period as the influence from the coronal hole HSS wanes.

The effects of CH53/- are evident on STEREO A, with winds increasing to Elevated. MOSWOC Enlil suggests a gradual increase in winds through Day 1 (8 Dec) peaking around 550 km/s on Day 2 (9 Dec) and is currently considered good guidance.

Geomagnetic activity is expected to be initially Unsettled, with Active intervals likely and a Chance of further G1/Minor Storms on Day 1 due to the arrival of the HSS. Geomagnetic activity is expected to return to Quiet by Day 2 (9 Dec), with a diminishing chance of Unsettled intervals.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	60	10	5	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Nil CMEs expected.

Figure 2a: MOSWOC Enlil showing solar wind enhancement. Uncertainty in duration.

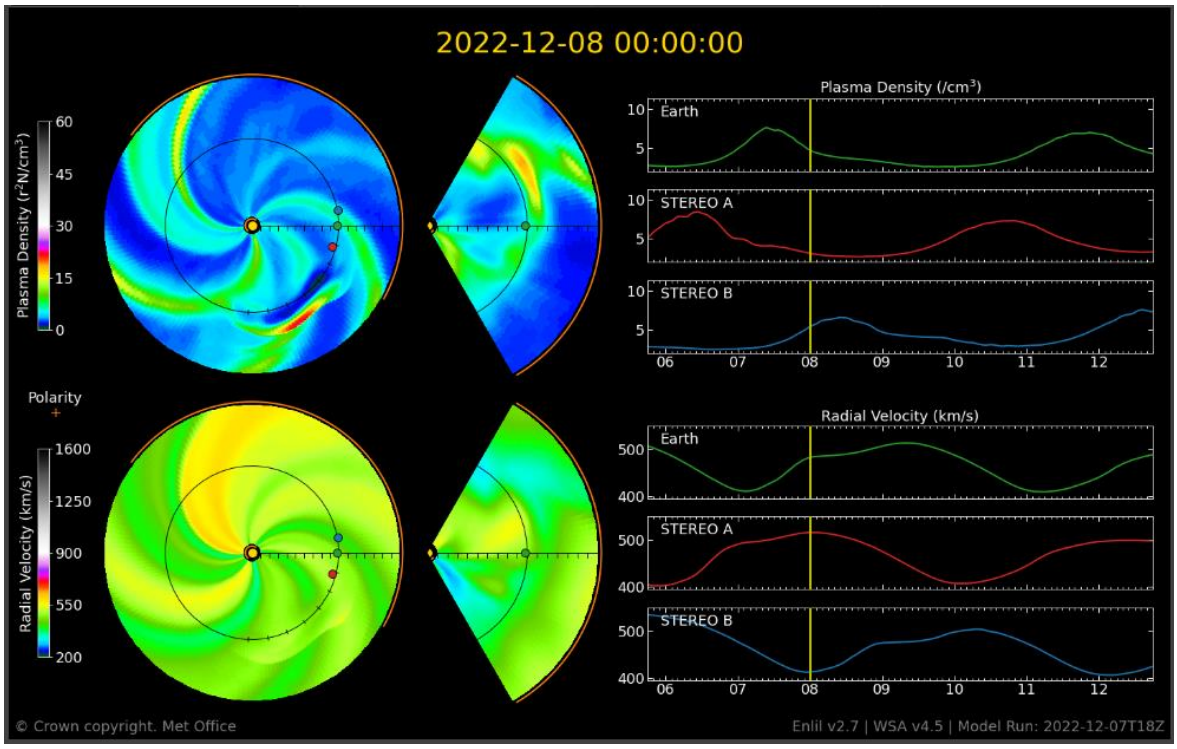

Figure 2b: MOSWOC SWPM. Onset of HSS faster than modelled. Peak values 550-600km/s accepted.

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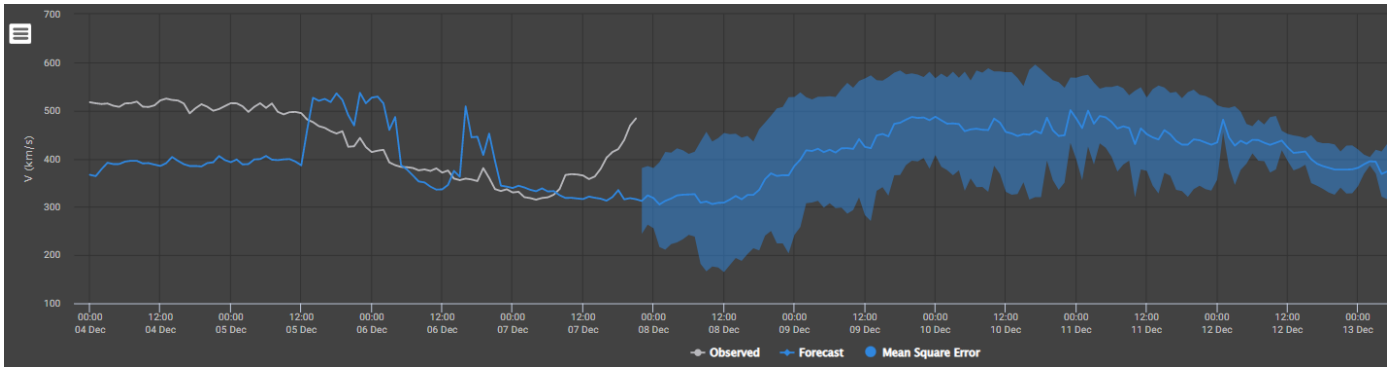

Radio Blackouts - X-Ray Flares:

Solar Activity has been Low over the last 24-hours, with occasional C-Class flares, becoming frequent for a time through the UTC afternoon, including a C5.88 peaking at 07/1304 UTC originating from AR3157. Activity is likely to remain at Low levels, with a daily Chance of increasing to Moderate through the period, post likely a result of flares emanating from AR3153 or AR3157.

There are currently seven numbered and one unnumbered sunspot regions on the visible disc. By far the largest group on the disc remains AR3153 (Fho/Beta-Gamma), now centre disk. This region has remained relatively stable with some slight development and minor flare activity. The second largest spot group, AR3157 (Esi-Beta-Gamma), in the northeast has shown some minor growth. The remaining numbered regions are all relatively small, and have shown little change in the past 24-hours. The unnumbered region in the northeast is growing slightly, with penumbra becoming better defined. Bi-polarity of this region lies along the meridional axis, with an associated increase in the potential for instability.

One further region may emerge over the eastern limb through Day 1 (8 Dec), otherwise all the sunspots likely to be present in the period are presently on the visible disc.

Despite the suggested complexity of the regions on the visible disc, this has so far failed to manifest in significant flare activity. As such, the percentage risk of M-class flares through the period have been maintained at lower levels than raw probabilities would suggest.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	30	30	30	30
Very Active	R3 to R5 X Class	No	2	2	2	2

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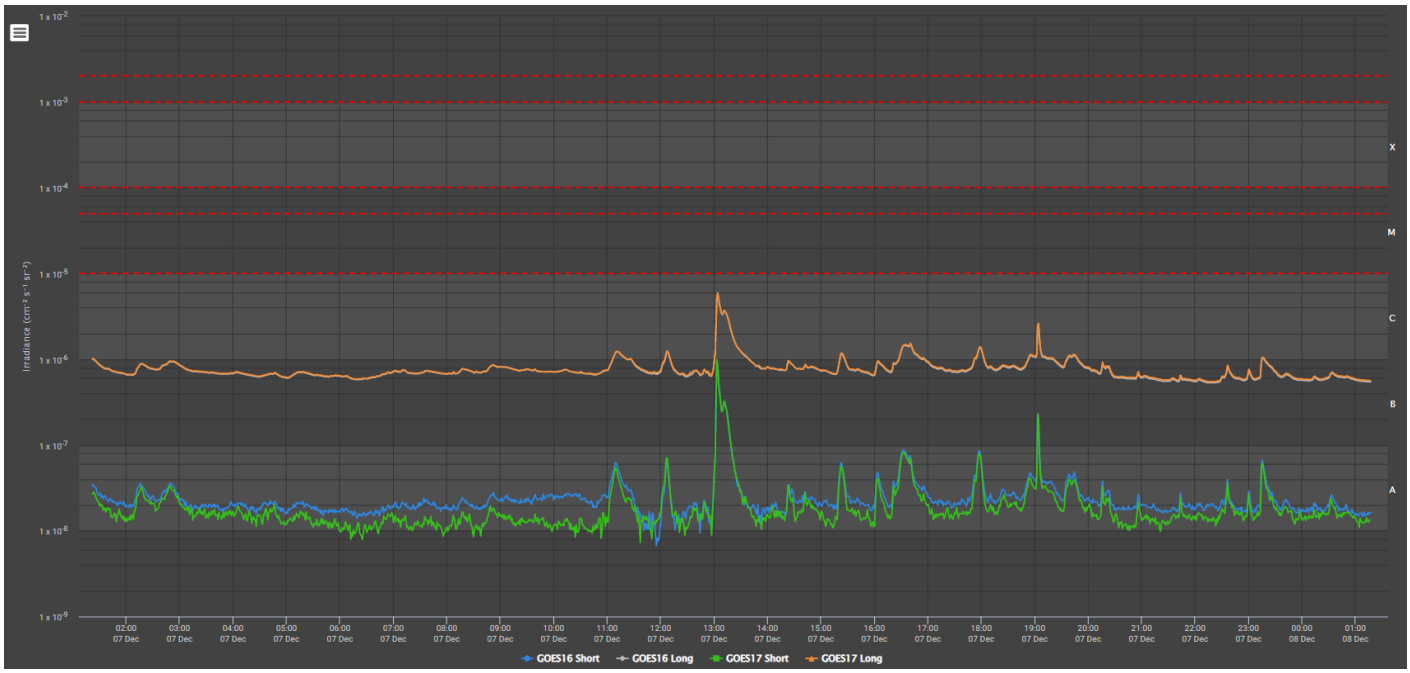
Figure 3: GOES16 X-Ray flare trace showing Low activity.



Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) is expected to remain at Background levels throughout. However, there remains a daily very Slight Chance of seeing S1 or greater levels at GEO if any significant flares were to occur. Probabilities are representative of raw values and current sunspot classifications.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2 MeV), as observed by GOES16, was demonstrating a diurnal oscillation between Moderate and High flux levels, but fell to Background levels around 07/1745 UTC where it has since remained. This is likely as a result of geomagnetic activity from the arrival of CH53/- causing disruption to and compression of the radiation belt. As influence from the HSS wanes, electron flux levels are expected to recover by Days 2 and 3 (9-10 Dec).

Levels of electron fluence are currently at Background levels, but very close to the Active threshold (1e8 integrated pfu). A probable decline is expected through Day 1 due to the arrival of the HSS, with a recovery from Day 2 (9 Dec), once more giving a Chance of Active fluence levels.

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Confidence in the timings of recovery of levels of electron flux and fluence is relatively low, as the driving coronal hole during the period is much-changed from the last rotation.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	20	40	40	40
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 4a: GOES16 Electron Flux trace. Shows disruption likely caused by geomagnetic activity.

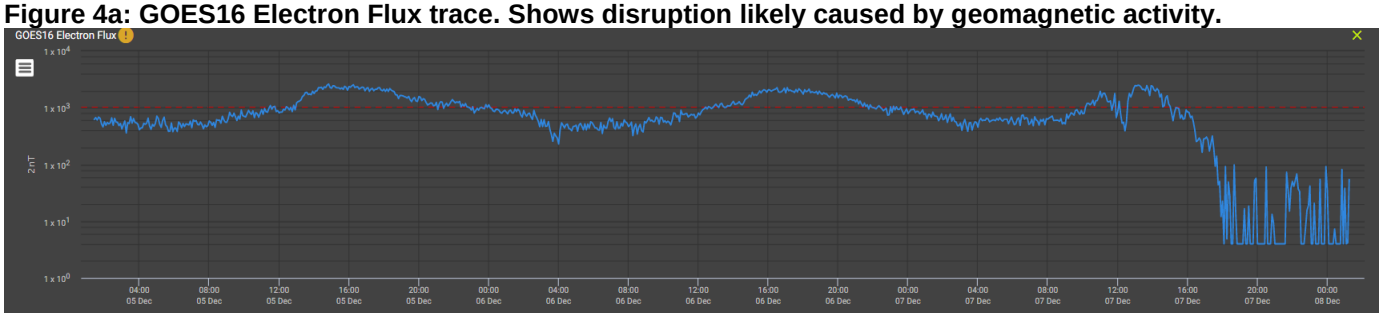
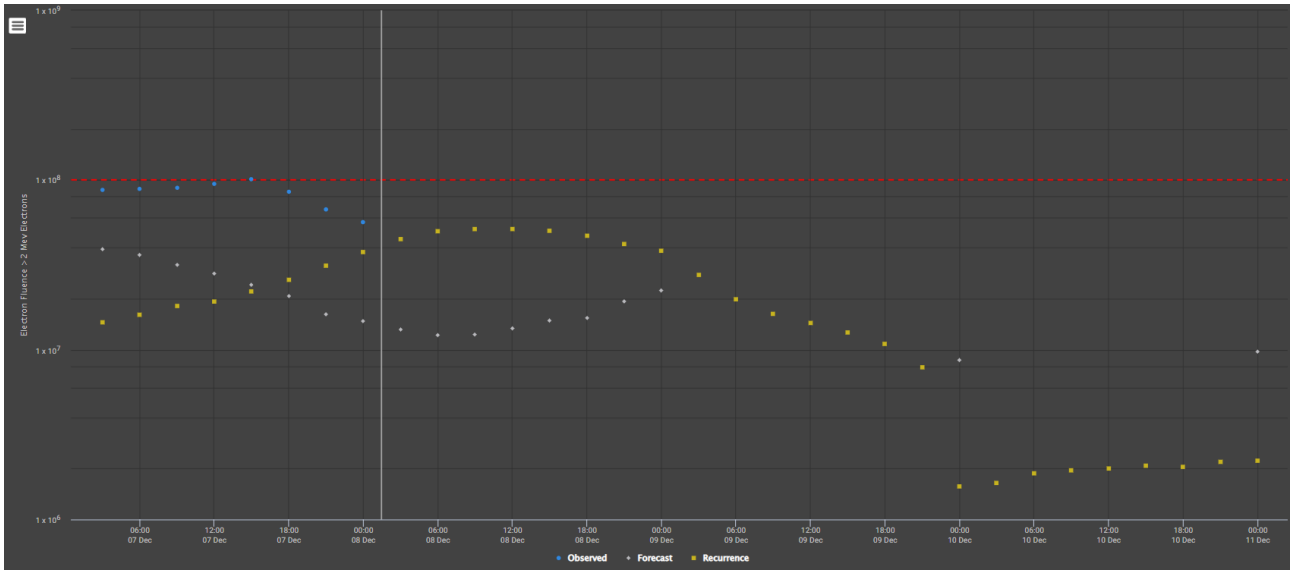


Figure 4b: MOSWOC REFM. Not considered to be giving a good steer due to marked differences in coronal hole between rotations.



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